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Student-Designed Mapping Project as Part of a Geology Field Camp

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ABSTRACT

During the summer of 2012, the Louisiana State University (LSU) field camp program was affected by close proximity to the large Waldo Canyon Fire in Colorado Springs, CO, as well as by a fire incident on the field camp property. A mapping exercise was created that incorporated spatial data acquired on the LSU property to investigate research questions that were developed by the students. The ownership of the design, implementation, and reporting of the project from start to finish generated strong personal interest from the students and led to enhanced academic performance. Four of the six student groups that conducted this exercise chose to investigate questions related to wildfire on the property. The influence of the events of the summer was strong in shaping their interest and project design. Furthermore, the connection to the wildfire events and the camp property itself strengthened the interest level of the students and the sense of ownership of the projects. While the specific events of that summer field camp program are not possible to re-create, we show here that the strategy of allowing students to control as much of the project design as possible is a good strategy for enhancing student interest and thus strengthening the achievement of learning objectives. This can be achieved while still providing students with the academic content as appropriate for the curriculum of a given course. *© 2015 National Association of Geoscience Teachers*. [DOI: 10.5408/14-003.1]

Key words: field camp, mapping, learner-centered teaching, geoscience education

INTRODUCTION

Geology majors across the country are required to earn credit in the area of field geology as part of their degree program. Often, this credit is earned away from the student's home campus while participating in a "field camp." The field camp experience typically involves a "capstone" course, which requires the student to apply knowledge that they have acquired throughout their major coursework. This is most commonly done through the teaching of geologic mapping. Typically, a field camp is a 5 or 6 week intensive experience in which the students are working in the field all day for most days, with some days spent in the office generating maps, lithologic descriptions, cross sections, stratigraphic columns, and writing reports on the geology of their study area (Baker, 2006). While most students will not be utilizing the skill of geologic mapping in their professional endeavors, field camp is important for many other purposes, including investigating multiple working hypotheses, completing a study with multiple data types, and studying the regional geology of an area to develop an appropriate sense of the scales of time and space, which is critical in all types of geologic work (Pyle, 2009; Stokes and Boyle, 2009). While these are skills that employers desire (Dohms, 2011), students often do not see these more abstract benefits. In addition to solidifying the education of a geology major, this experience usually serves as a "rite of passage."

During the summer of 2012, the field camp of Louisiana State University's (LSU) Department of Geology and Geophysics was impacted by a series of events related to wildfire. These events had an effect on the normal operation of the field camp and shaped the direction of course exercises. Here, we investigate the impact that these events had on the learning of the students who were involved in an ad-hoc student-designed project.

The LSU field camp is conducted on a property near Colorado Springs, CO, that is owned and operated by the university (Fig. 1). The field camp program has run annually since 1928. Therefore, the students, most of whom are residents of Louisiana, hold a strong nostalgic connection to the camp. During the summer of 2012, the costliest fire in the history of the state of Colorado, the Waldo Canyon Fire, broke out approximately 14 mi (22.5 km) from the camp property. This fire made national news, caught the attention of the parents of the students, and dominated the attention of the students at camp as it spread and grew larger each day. While the students were never in danger, the scale and proximity of the fire were significant factors in distracting student attention. This fire also caused some planned mapping exercises to be changed by the instructional staff due to the loss of access to planned study areas. One week after the outbreak of the Waldo Canyon Fire, a vehicle fire occurred in a wooded portion of the LSU property, spreading into surrounding brush and trees before being contained and extinguished by local wildfire crews. During the LSU fire, the camp was evacuated according to emergency protocol. The students once again had wildfire rather than geology at the forefront of their attention.

During the final week of the course, an academic exercise was developed and implemented in response to the closure of the planned project area. The project provided training for the students in the skills of collection of spatial data using global positioning system (GPS) receivers and generating maps using geographic information system (GIS) software. The design of the project required students to use

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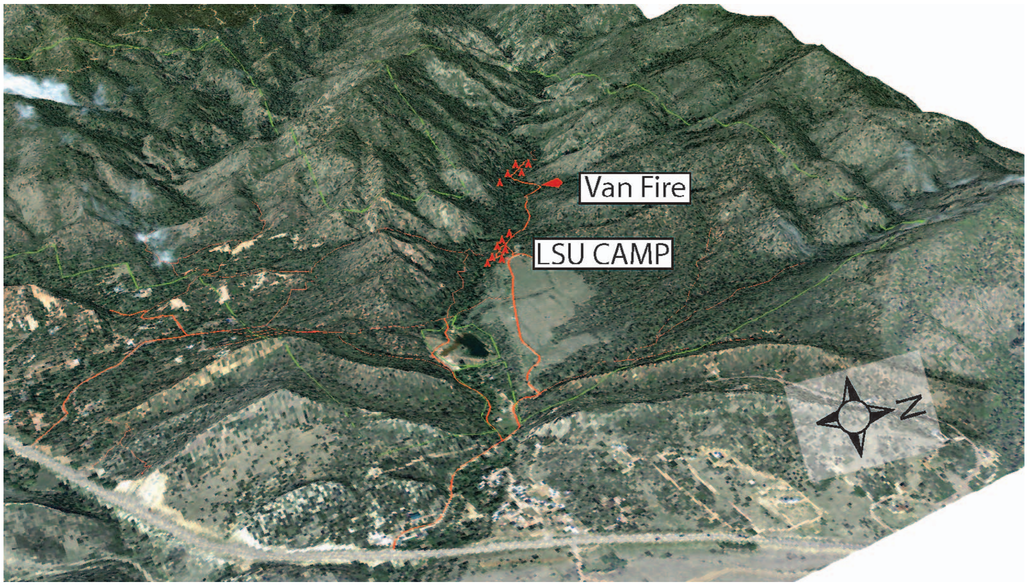

FIGURE 1: Three-dimensional image of the LSU camp property (color version of this image available online at http://dx.doi.org/10.5408/14-003.1). The green outline shows the boundary of the property. The thick red lines show the location of roads that can be driven on with vehicles. The thin red lines are hiking trails. The red teepee symbols indicate the location of student and staff cabins in Lower Camp and Upper Camp. Also indicated is the location of the LSU van fire.

the 1,300 acre (5.25 km^2) LSU property as their field area and source of data.

This project was built on student design of research questions, investigation strategies, and reporting. We present here findings of a curricular design that proved impactful on our students in several ways. The events of the world around them impacted the project design of the students. The connection between their research project and their surroundings enhanced their connection to project design, research, and reporting. The connection between their research project and their surroundings enhanced their achievement of the learning objectives of the project.

This study is significant because the importance of the geologic field camp experience has been under scrutiny in recent years (e.g., Dohms, 2011). The number of traditional field camps has declined (Whitmeyer et al., 2009), while the industry and alumni maintain the view that the importance of the experience has remained (Uzunlar and Lisenbee, 2010; Petcovic et al., 2011). Many field camp programs have been modified to provide specialized training (Bauer et al., 2009; Kelley, 2011), while others have been developed that provide experience studying in geologically unique settings (e.g., Gravley et al., 2009; Liberty et al., 2011), or in specific geologic subdisciplines (Douglas et al., 2009). This project aims to contribute to the national efforts of field camps to develop exercises that are effective in teaching the core principles of geology while maintaining student enthusiasm, and providing real-world problem-solving experience (Burchfiel, 2007; De Paor and Whitmeyer, 2009).

This experience of instructional innovation that was required due to circumstance led to student-designed projects that possibly had better outcomes than the project that was initially planned. Kelso and Brown (2009) show that project-centered teaching improves self-confidence and student retention of material. Thomas and Roberts (2009) indicate that immersion in one course of study improves learning. In addition, learner-centered activities are well documented to be effective teaching tools (Blumberg, 2009). Geology field camps are an ideal setting for this type of immersive, learner-centered teaching, and therefore, projects such as the one described herein could be successfully implemented widely in field camp programs.

BACKGROUND

Course Structure

The Charles Barney Geology Field Camp Program in the Department of Geology and Geophysics at LSU is taught each summer for 6 weeks at the university's fixed-base field camp outside of Colorado Springs, CO. The students, instructional staff, and support staff live on the property in cabins, eat in the dining hall, and commute from camp to additional study sites in a combination of owned and rented vans.

A course titled "Field Geology" is taught to junior- and senior-level geology majors. The prerequisite courses are paleontology, mineralogy, igneous and metamorphic petrology, sedimentology, and structural geology. In recent years, the class size has ranged from 20 to 36 students. Most of these students are geology majors at LSU, but each year, several students from other universities take this course with LSU during the summer in order to acquire the field geology credit to transfer to their home department to be applied toward their geology degree. The project described here was carried out during the 2012 field camp session, during which there were 36 students. These students were all traditional-aged college students from southern states, primarily Louisiana.

In 2012, the 6 week course consisted of six weeklong projects. The first 2 weeks were spent on the LSU camp property, where Permian through Upper Cretaceous sedimentary strata are near vertically oriented and are nicely exposed. Week one involved the construction of a detailed stratigraphic column of these formations. During week two, geologic mapping of the camp property was conducted. In these first 2 weeks of the course, the students spent 5 full days in the field each week, during which they became quite familiar with the geology, topography, hiking trails, roads, buildings, historic landmarks, and vegetation of this 1,300 acre (5.25 km^2) property. During week three, the students completed a geologic mapping exercise with more complex structures. Week four's project focused on mapping intrusive and metamorphic rocks. Week five was dedicated to stratigraphic correlation. During week six, the students were divided into two groups of 18 students to do projects that involved more specialized discipline-specific investigation. This strategy was implemented because it has been shown to work in other field camp programs (e.g., Bauer et al., 2009).

Wildfire Activity

During week four of the course, the Waldo Canyon Fire broke out on the west side of Colorado Springs. The fire forced the evacuation of 32,000 Colorado Springs residents and destroyed 346 homes, making it at the time the most destructive fire in the history of the state. U.S. Highway 24, the primary pass through the mountains heading west out of the city was closed for several weeks, and the U.S. Air Force Academy campus was partially evacuated. This fire was very much in the attention of the students. The smoke could be smelled at the LSU camp, which was ~14 mi (22.5 km) away. The fire was on national news broadcasts. Parents, alumni, and university administrators were calling the camp regularly to be sure of the safety of the students and staff as well as the field camp property. Students were aware of the acreage of the burn zone, the percentage of containment, and the number of destroyed homes on a daily basis. One of the three projects (mapping karst features) planned for week six was to take place in Williams Canyon, a locality near Manitou Springs, CO, and along U.S. Highway 24. This locality was under mandatory evacuation and therefore not available.

On the Saturday that ended the fifth week of camp just after dinner, one of the LSU vans caught on fire due to a mechanical issue. The fire occurred far up a valley on a dirt road in a heavily wooded area of the property. The van fully burned and was completely destroyed. When the fire was discovered, the entire camp population was evacuated, and three local firefighting forces responded and fortunately were able to put out the fire before it spread and grew out of control. The fire could have very easily spread throughout the LSU property and the adjacent portion of the Pike National Forest—areas that are inaccessible by vehicles. The risk of wildfire had for some time been a topic of discussion between the LSU Department of Geology and Geophysics and the Highway 115 Volunteer Fire Division, the firefighting force serving the camp. These discussions had led to hazard mitigation measures, such as widening of trails on the property for all-terrain vehicle (ATV) access, and the cutting back of vegetation along the camp road to ensure swift access by emergency vehicles in the case of wildfire.

This fire was a particularly stressful event for the students, considering that they had been thinking and talking about wildfire for the previous week and then experienced a near-miss so close to home.

PROJECT DESIGN AND OUTCOMES

The fires in the region and on the camp property caused planned exercises to have to be changed. One half of the students participated in the planned stratigraphic exercise, while the other half participated in a new GIS-based mapping activity that was designed by the instructors in response to the situation and aimed to utilize the background and skills that the students had acquired through the first 5 weeks of the course. Selection of students into the two groups was done by the instructors while taking student preference into consideration. Nearly all of the students who did this project indicated that they wanted to work on a GIS-related project rather than a stratigraphy-related project.

The goals of the exercise were multifaceted. First, a mapping exercise needed to be designed that built on the previous exercises of the course and introduced students to the principles of GIS. Also, the project aimed to lead students to develop maps that could be useful and practical to LSU, the community, future students, or any other users of the property. The learning objectives were (1) use of the principles of geospatial data analysis to solve a problem; (2) development of successful strategies for geospatial project design from data collection, to synthesis, to reporting; and (3) development of professional skills related to group work and communication of results.

Instruction for the project began with explanation of the principles of spatial data, the functionality of GIS software, and the abilities and applications with regard to treating spatial data. Students then were guided to think of as many types of spatial data as they could that could be collected on the LSU field camp property. The camp was utilized as a resource. Due to their work during the first 2 weeks of the course, and living on the property for 5 weeks, the students were very familiar with the camp, somewhat familiar with the logistical operations, and aware of lines of investigation that might be possible. It was then discussed which types of data might be collected on the ground (i.e., geology, trail locations, water lines) and which of the data would be acquired from outside sources (i.e., precipitation records, vegetation, elevation, and slope).

The 18 students who participated in this project were divided into six groups of three students. The next step was for the students to consider what types of questions might be investigated using these data sets. The students then developed hypotheses that could be investigated using the available data. The students were encouraged to think freely and creatively about what might be investigated. They did not yet have much insight as to how GIS software packages worked or the specifics of how the data would be combined, overlayed, etc. The students were told to consider that any way they wanted to combine or compare different data types would be possible. This allowed them to be creative and was a key instructional strategy in this project. All groups were assigned to collect some common spatial data, such as bedrock geology and locations of buildings, trails, roads, power lines, and water lines. They would all collect these in addition to the data that were needed to investigate their specific research question.

They were then given 3 d to collect all of the data that they needed to incorporate into their project. They used basic handheld GPS receivers and kept notes on their data in field notebooks. Each evening, the instructors conferred with each group to discuss and modify hypotheses and data collection strategies. As the week progressed, the students were taught about the difference between shape files and raster files, as well as how they are used in conjunction with each other in GIS software in order to enhance their thinking about the types of data they were collecting and how they could improve the data collection strategies to effectively investigate their research question.

On the fourth and fifth days of the project, the students were taken to the Rampart Range Campus of the Pikes Peak Community College to use the GIS laboratory. They were taught the software commands used to combine and communicate the different data sets that they had built or acquired externally. Each group had a common assignment—to make a digital geologic map of the camp. This skill was one of the original goals of the week six volcanic mapping exercise that had to be cancelled. In addition to the geologic map, each group created a map or multiple maps utilizing new data that resulted from their investigation. They presented their projects to the rest of the class. In each presentation, the groups explained what the hypothesis or problem was that they had investigated, what types of data they had collected and utilized, how they combined or manipulated that data, and the results of their investigation.

The six student groups developed six unique projects to investigate. The six topics of investigation were wildfire risk, difficulty of wildfire fighting, a comprehensive trail map, lightning strike potential, landslide potential, and a surface water drainage analysis. The development of the first four projects were related to wildfire and seemed to be directly influenced by the events of the summer and so are explained in further detail here.

Group 1: Wildfire Risk

This group developed a map of areas of low to high risk for the start of a wildfire on the LSU property (Fig. 2). They used the slope of terrain, proximity to streams and/or the pond, and proximity to the one road on the property. The students based their analysis on the idea that human activity would be the most likely ignition source of a wildfire. On the 1,300 acre (5.25 km^2) property, the population is usually confined to the camp area (Fig. 1). Therefore, areas within a 30 m buffer of the road or buildings were given a high risk value. Areas within 10 m of the stream or the reservoir were given a value of low risk due to the moisture present there. Also, areas of highest slope were given a value of low risk due to infrequent human activity. The group applied a weighting system to the values of proximity to roads and trails, proximity to water, and ground slope to create five categorical values ranging from low risk to high risk (Fig. 2). They found that the areas of highest risk were those closest to the roads and the residential area of the property.

Group 2: Difficulty of Wildfire Fighting

This group aimed to create a map that showed the easiest to most difficult areas of the property in which to fight fire. The proximity to roads was given the value of the easiest areas to fight fire due to fire truck access. A 50 m buffer around roads was given the value of easy. A 20 m buffer from trails was decided to be easy for firefighting due to ATV access. A high amount of ground cover was rated difficult for firefighting, while lower amounts of ground cover were rated easier. Finally, the slope of the terrain was taken into account, such that steeply sloping terrain was deemed difficult for firefighting. These values were combined into five categorical values ranging from hard to easy (Fig. 3). The outcome of the firefighting difficulty assessment showed that the easiest places to fight wildfire are along the roads and in areas of flat terrain and low amounts of vegetation, such as the meadow.

Group 3: Lightning Strike Potential

This group used the factors of slope, elevation, and vegetation cover to assess potential for lightning strike. Interestingly, the motivation for this investigation is the assumption that lightning would be the most likely trigger for wildfire, as much of the camp property is remote and inaccessible to people (see Fig. 1). This is contrary to the assumption at the heart of group 1's project and led to some lively conversation during the presentations. This group received the lowest scores for this assignment because they did not treat the data in a robust way using the GIS software, but rather "eyeballed" the results when making the map shown in Fig. 4. Their motivation to investigate this project is still relevant here.

Group 4: Detailed Trail Map

This group created a map of all trails on the property. The trails were ranked by ease of use with four difficulty categories. The difficulty was based on amount and type of vegetation, type of bedrock, and slope of terrain. During their presentation to the class, they explained that the motivation for the creation of this trail map was to share it with the LSU Field Camp Program leaders as well as the local volunteer firefighting force. They included on the map symbols that show the trails that are accessible to ATVs because they had become aware that this is often a critical issue for wildfire crews in gaining access to fires. Discussion during the presentation by this group showed that the results were relevant to the projects of the other groups as well. It is interesting to note that when the students applied their resulting maps retroactively to the van fire that occurred on the LSU property, the results were consistent with the event. The fire started along the road between Lower Camp and Upper Camp (Fig. 1) in an area that was deemed to be a high risk area (Fig. 2). The firefighting units that responded were able to quickly and effectively put the fire out, which is consistent with this fire being located in an area rated as "easy" on the map of firefighting difficulty (Fig. 3).

We also point out here that the primary focus of this exercise was not on the GIS application, but rather on the design of a project that investigated a problem by forming a hypothesis, gathering data, and utilizing that data to test the hypothesis, as well as visual and oral communication to their peers. The GIS skills were the avenue for accomplishing this. The students created the maps shown in Figs. 2–5, deciding on all aspects of design (colors, scale, title, layout, etc.). Each group then gave a professional-style presentation to the class outlining the goal of their project, the types of data that

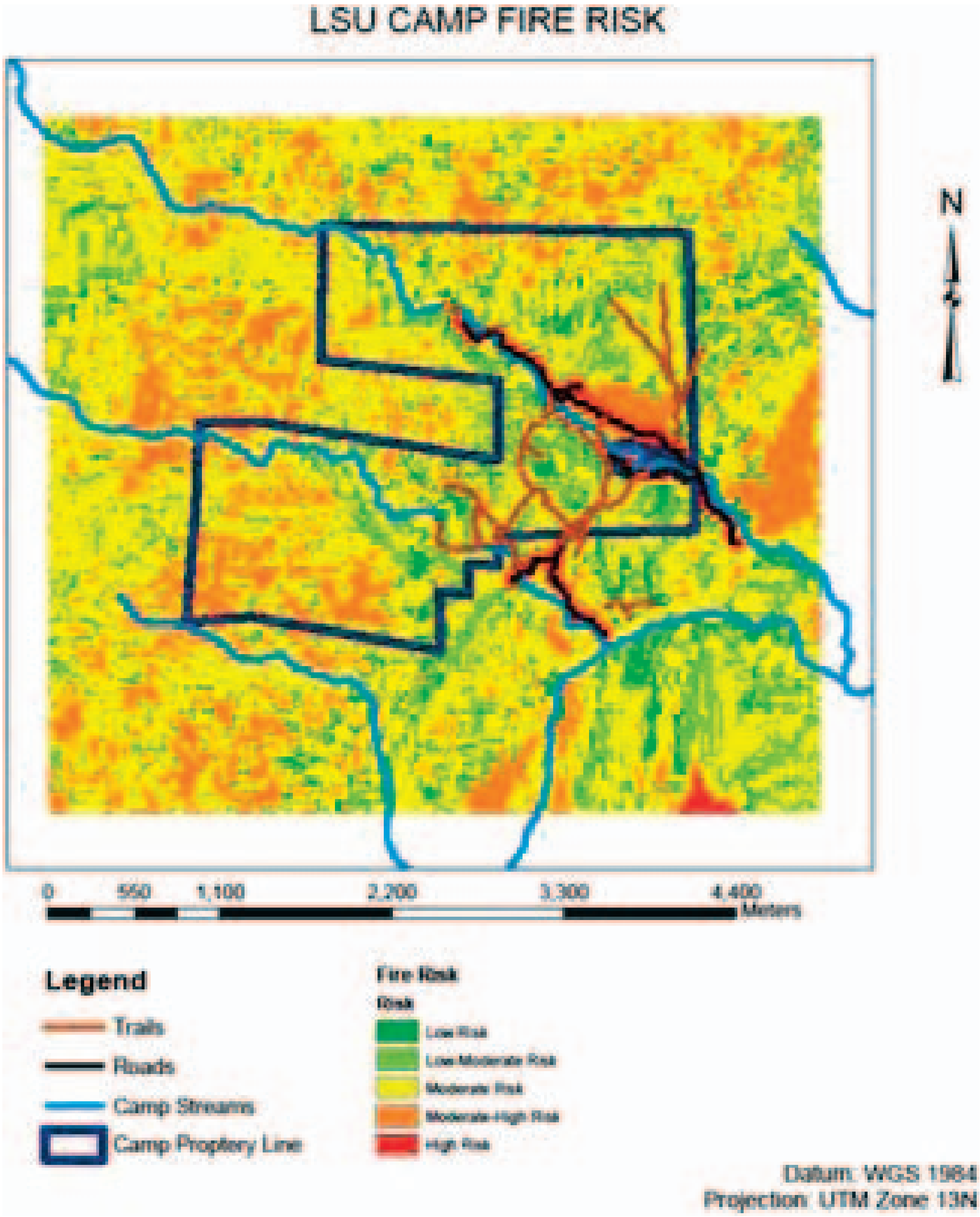

FIGURE 2: Student map showing determined risk of wildfire on the LSU geology field camp property. Color version of this image available online at http://dx.doi.org/10.5408/14-003.1.

they chose to collect, how they collected those data, how they used or combined those data types, the findings that the maps yielded, as well as the relation to the findings of the other groups. This was an excellent opportunity for them to synthesize the project and to respond to comments and questions from their peers. The presentations from all groups yielded active discussion.

Practical Outcomes

The maps that were generated by the groups were shared with the Highway 115 Volunteer Fire Division. This force had large, hard-copy topographic maps of the area of the LSU field camp on hand, which included some roads and buildings. The student-created GIS maps of the camp include much more detailed locations of all buildings, roads, trails, and infrastructure on the LSU property. These maps will be useful in any future wildfire incident on the property or adjacent properties, as well as fire prevention plans. These practices will enhance the ease of potential firefighting by expanding access with trucks and ATVs, and they will also lower the risk of fires starting due to human activity on these roads and trails.

Learning Outcomes

Student Surveys

The students who participated in this project were contacted after leaving camp and asked to participate in an online survey regarding their perceptions of the project. The students answered 15 questions on a Likert scale ranging from −5 to 5, with those numbers usually relating to

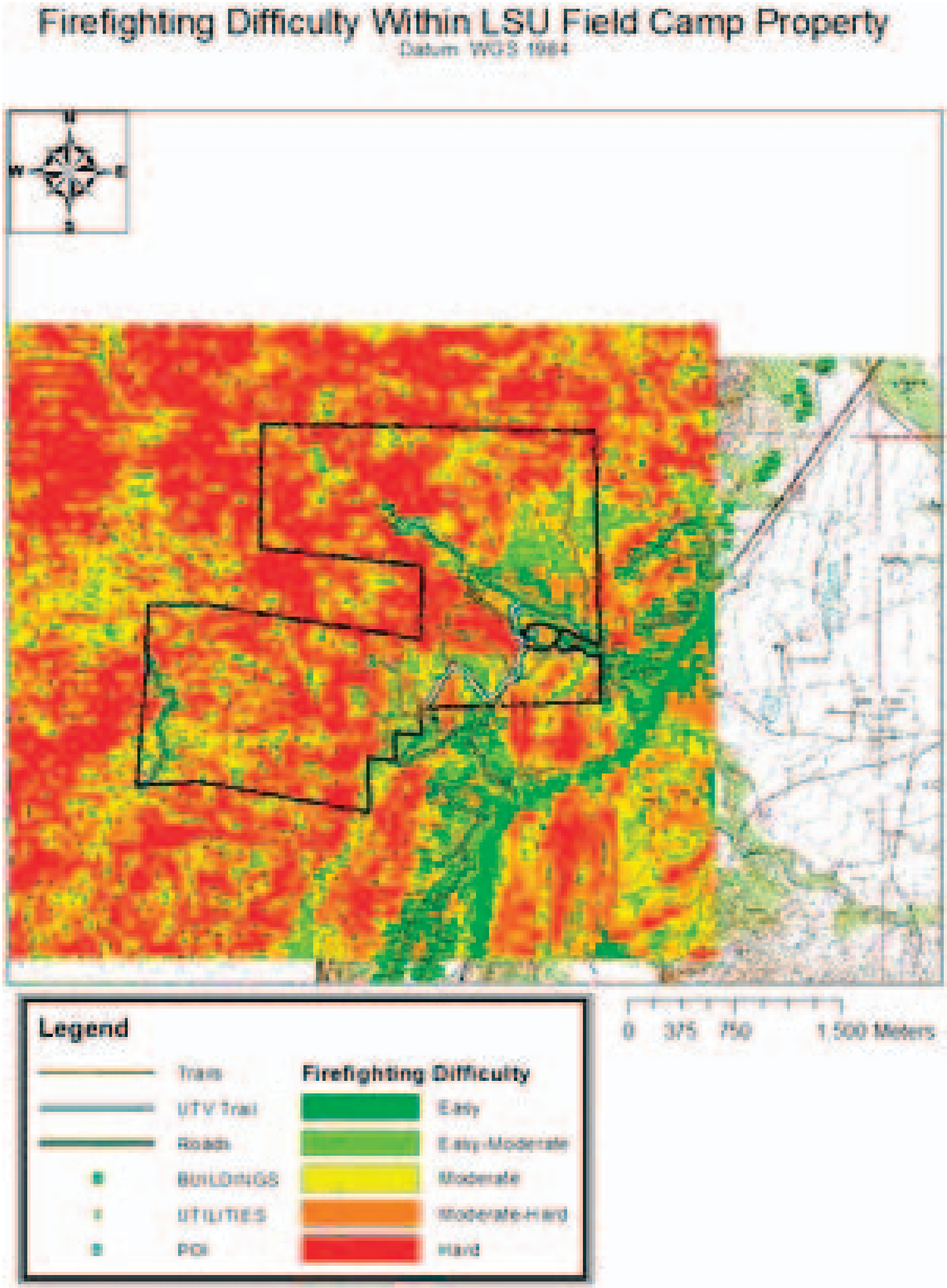

FIGURE 3: Student map showing determined firefighting difficulty on the LSU geology field camp property and surrounding areas. Black line outlines the LSU property. Color version of this image available online at http://dx.doi.org/10.5408/14-003.1

"strongly disagree" and "strongly agree," respectively. Qualitative data were collected along with these quantitative data, as each question also included a short answer component that asked the students to expand on why they answered the question a certain way. Due to the unexpected nature of the need for this project, there were no pre-assessments. The responses to the postcamp survey indicate the project was a successful alternative that allowed the students to utilize preexisting knowledge and synthesize it into an original student-designed project while learning the basics of GIS project design and implementation. A summary of the survey data is presented in Table I.

Of the 18 students involved in the student-run GIS project, eight of them responded to our survey request. One of the eight students accepted the request and only answered the first question. Due to the lack of data for the additional questions, that student's response was not included in the analysis. A 39% usable response rate was observed. The responses included students from multiple groups, with three of the respondents reporting to have

FIGURE 4: Student map showing determined risk of lightning strike on the LSU geology field camp property. Color version of this image available online at http://dx.doi.org/10.5408/14-003.1.

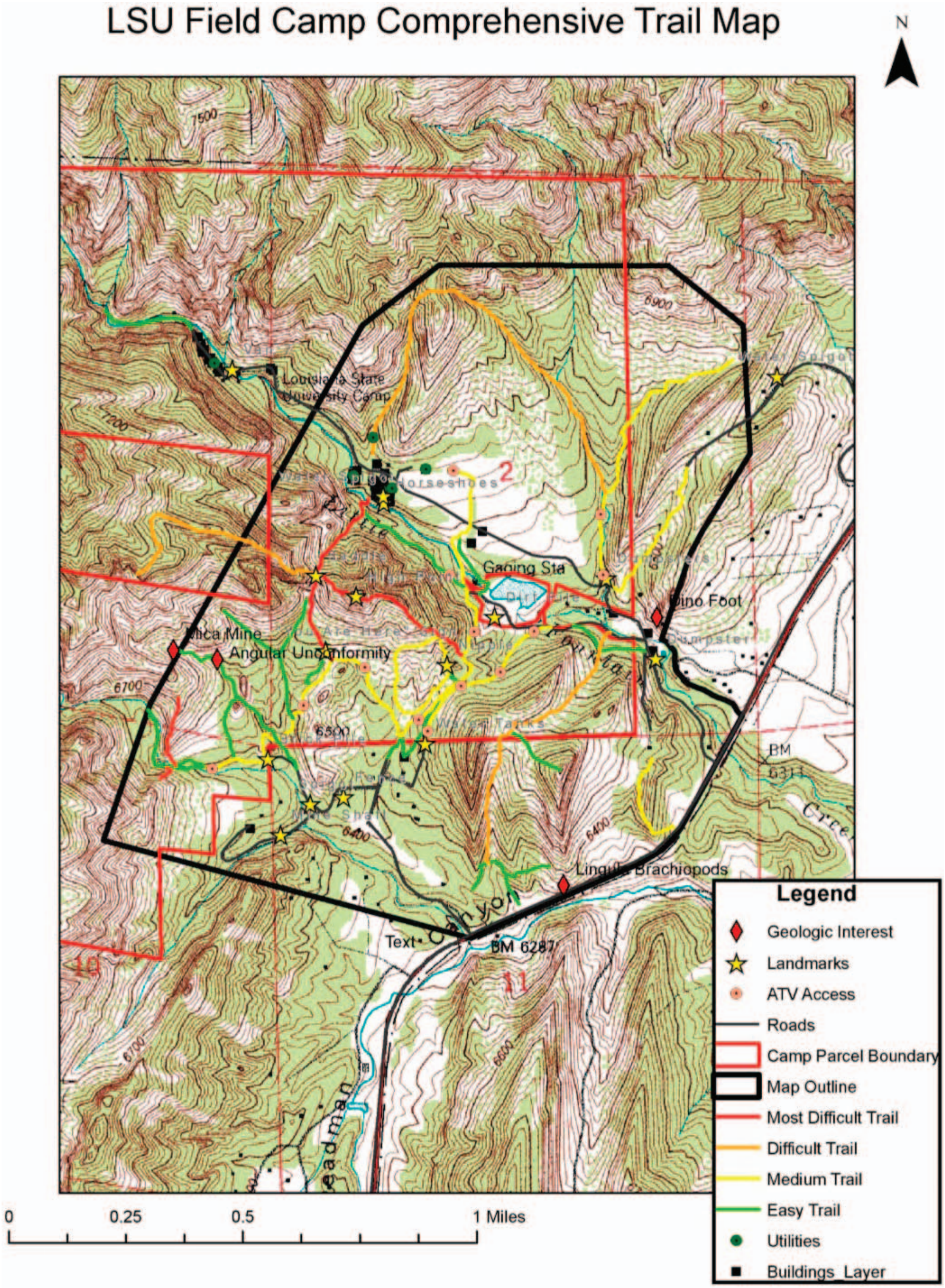

FIGURE 5: Student map of trail coverage on the LSU geology field camp property, including ease of travel. Color version of this image available online at http://dx.doi.org/10.5408/14-003.1.

TABLE I: Selected survey questions, the mean response score, and selected open responses provided by students.

Question Area	Survey Questions	Mean Response	Selected Student Open Responses
Practical use of GIS project	Do you feel that you learned valuable GIS skills during the field camp GIS project? Why or why not?	Strongly agree (4)	It was my first time dealing with the software and it was invaluable to have hands on training with a project I had been working on all week.
	Do you feel that the GIS project at field camp met your learning expectations? Why or why not?	Strongly agree (4)	I had never had the chance to use GIS software before and the field camp project provided a useful introduction.
	How useful will the field camp GIS project be in a real-life setting?	Strongly agree (4)	The GIS project enabled the students to work on a project that could be used in a real life setting. I liked this because it gave a glimpse of how GIS can be used outside of a classroom setting.
	How useful are the maps that you created for your field camp GIS project to other people? Why or why not?	Strongly agree (3.57)	Very useful. We were able to map fire susceptibility in the LSU field camp area.
	Did your experiences during the first 5 weeks of camp influence your project design? Why or why not?	Agree (3)	Absolutely, because I had been studying the field of interest almost everyday before.
	Do you view GIS as a practical skill? Why or why not?	Strongly agree (4.71)	GIS's ability to clearly communicate large volumes of data make[s] it a virtual necessity in the Earth Sciences.
Influence of personal project design	Did you have a different level of pride (more or less) in the map(s) that you created for this project than the maps that were made for your previous projects? Why or why not?	Somewhat agree (1.57)	1. To put it simply, these maps felt like they had a personal touch to it, i.e., we completed a project of our own design. 2. As the difficulty of each project was enormous, I would say I was just as proud of each finished project.
	Do you believe the knowledge that your map may have been shared with local firefighting forces influenced your feelings about the project? Why or why not?	Strongly agree (3.86)	Yes very much. Being at field camp during the fires added to the incentive of producing a map that could be useful to local firefighters.
	Does the fact that your project was an original idea of your group (no students have done that project before) influence your feelings in your product(s)? Why or why not?	Strongly agree (3.86)	While I would hesitate to increase the number of original project ideas at field camp based on the fact that there are certain things that need to be taught and learned at camp for it to be effective, I would agree that it was very cool to be able to come up with and carry out an original project.
	Did you work harder on the maps for this project than maps for the previous projects? Why or why not?	Somewhat disagree (−1.14)	I worked very hard on all projects.
	Do you think a student-designed GIS project should be done again as part of the LSU geology field camp? Why or why not?	Strongly agree (3.43)	The project really forced us to think creatively and beyond traditional geology.
	Do you think that the project that you designed and investigated should be done again by another group as a part of this exercise? Why or why not?	Agree (2.71)	Yes, because it had an obvious purpose other than learning.
	Did you find the field camp GIS project to be interesting or boring? Why?	Agree 3.29	I would say it was the most interesting project I have completed in all of my geology experience.
Attachment to place after completion of project	After the completion of your field camp GIS project, did you feel an attachment to the map location? Why or why not?	Strongly agree (4)	Yes, it's hard not to grow attached to a place you worked so hard in.
	Can you still visualize your field camp GIS map in your mind? Why or why not?	Strongly agree (3.57)	Yes. I hiked every single one of those trails.

worked on one of the four fire-related projects. The results of these surveys are discussed below. Parenthetical numbers are average scores of responding students. The authors note that, due to the low numbers of students, the quantitative analysis of survey data should only be used to further verify the statements made by the students in the short answer portions of the survey. Narrative summary analysis was used to identify themes within the open-ended survey responses.

RESULTS AND DISCUSSION

Influence of Personal Project Design

The student-driven design had a profound impact on students' feelings toward the project overall. Statements such as, "I would say it was the most interesting project I have completed in all of my geology experience," were given by most of the students. When asked about the level of motivation to work harder on this project, students did not necessarily feel that they put more work into this project than other field camp projects, but they did include comments such as, ". . ...this project most definitely had a personal feel to it and I was very motivated to put my best work forward."

It was interesting to note that those students who worked on the fire-related projects ($n = 4$) expressed a greater interest in their project (4.25 strongly agree) than the students that worked on other projects (3.30 agree). While this difference in response score is not statistically significant, the fire-related project students made statements such as, "It was very exciting to be part of the first group of students to work on such a project." Though they did not indicate that they worked harder on this project than others earlier in camp, making comments such as, "I put equal effort into every project at field camp," the data suggest that those students who worked on a fire-related project feel that they worked harder than did their student counterparts who did not work on fire-related topics. A student not working on a fire-related topic commented, "I would say I worked less on this project. It was not as time and labor intensive as some of other projects." They identified this project as being less physically demanding than previous projects, "Sitting behind a computer was much easier than chasing outcrops." It is unclear why there was a disparity between these students, but it may be linked to the idea that the students working on the fire-related projects felt that their work was more worthwhile and could be used by local firefighters for safety of the camp property as well as other students in the future. Comments such as, "Our intention was to facilitate forest fire prevention measures so I would be most pleased if it were able to help the local fire-fighters," by students working on fire-related topics further support this assertion. Upon further analysis, it was discovered that the students who worked on the fire-related projects saw on average a slightly higher level (4.25 strongly agree vs. 2.66 agree) of usefulness in their work. Students in these groups made comments such as, "Our group believed that the fire hazard maps could be most helpful especially in helping with forest fire prevention measures." These same students also felt strongly about the influence of the first 5 weeks of camp on their project design as compared to those students that were not involved in fire-related projects. When asked about this influence, the students involved in the fire-related projects made statements such as, "absolutely because I had been studying the field of interest almost every day before." On the other hand, a student from the non-fire-related group made the comment, "Not really. We kind of struggled to come up with anything at all."

Professional Preparation

While field camp exercises should be designed to strengthen skills associated with observation and data collection, they also promote training for graduate school or the professional world (Marshal et al., 2009) through working comprehensively on complex problems often with a group of peers. In many of the geoscience-related jobs that the students will find themselves in shortly after their field camp experience, problems need to be solved through a design of their own. Field camp provides this experience in a way that other courses in the geology curriculum do not. This project built student confidence through design, analysis, and reporting practices throughout the course of the week. We find this professional preparation to be an important indicator of the success of this project as suggested by Thomas and Roberts (2009).

The use of geospatial data in digital format is a rapidly growing industry. Most of those students who participated in this exercise chose it as their preference over the stratigraphy exercise, thus demonstrating their desire to gain some experience with GIS. It is important to note that the students identified the significance of GIS within the Earth Science fields. "GIS's ability to clearly communicate large volumes of data make[s] it a virtual necessity in the Earth Sciences." Most students came into field camp with a limited knowledge of GIS; however, they still understood the practicality of this software on a broader scale. "I had never had the chance to use GIS software before and the field camp project provided a useful introduction." Multiple students mentioned the benefits of this project, but they also identified the need for further education in this area. "I think GIS is a valuable skill, and learning how to use it in an applied way was useful. I am not sure if a one week crash course in GIS is a very effective way to truly learn the skill. I do not think much of the technical knowledge of how to use GIS stuck with me." Along with the practical use of GIS, all of the surveyed students also found the introduction of a student-designed GIS project at field camp to be a valuable endeavor. A couple of students also noted the overall practical use of GIS to their future career goals. "Am applying for a job as a geospatial analyst."

Pedagogical Benefits

This approach to the project was different from many other field camp projects in which the scope of investigation and the available data types are predetermined. In these traditional exercises, there is some sense of a correct map that the students are striving to complete. The students found excitement in the fact that this project was open ended, and the end result was not predetermined. This led to a sense of ownership of the project, which enhanced engagement and produced long-term learning, as shown by the survey data (Table I). The skills associated with generating each aspect of the project from start to finish will promote traits that make the student a better learner moving forward in future situations (Candy, 1991). In addition to providing the fundamentals of GIS to the students, this project enabled students to design and complete a short research project.

As is the case with many field camp mapping exercises, this project reinforced hypothesis development in the students. The project within each group was exploratory in nature. Each morning, the group held a planning session to revise their strategy. Each evening, the group reflected on the data that they acquired and their progress toward answering the question that they were investigating. This exploration style of learning combined with working in the field promoted an enjoyable experience for the students. Boyle et al. (2007) suggested that these positive influences on the affective domain of the students leads to improved learning and retention. The survey data in this study show that the students' perceptions were certainly that they had a more robust learning experience as a result of the project design.

These benefits will be explored in future work at field camp programs that are instructed by the authors. The benefits of student-designed projects can be tested in courses of many types, but we believe they are best tested in the field camp setting. In a 5–6 week field course, the ability exists for the students to be truly immersed in a research project and for the instructors to closely assess them. While student-designed projects can be implemented in traditional classroom courses, the impact that the project has on the student might be less due to the other distractions of life and other classes, and likewise, the impact of influential events could perhaps have less of an impact on the design of student projects.

The student perceptions of a strong gain of the spatial concepts of the exercise agree with the instructors' evaluation of the products of the project. The learning outcomes were successfully met at a high rate, and therefore the student grades were high for this exercise. The average score for this exercise was 90%. Those same students who participated in this exercise had an average overall score of 81% for the course.

Transferability

The transferability of this specific project is limited due to the nature of the circumstances that prompted the design and implementation. However, the strategy to allow students to be given control of the setup, evolution, completion, and reporting of a project within the parameters outlined by the instructors is widely applicable to field camps. Due to the immersive nature of field camp courses, the fact that most students come in with a strong background in geology, and by incorporating the field geology skills learned through the early stages of a field camp program, this type of exercise is ideal, particularly in the latter half or as the final project of such a course.

While this exercise was very specifically the result of the time and place in which it occurred, some strategies could certainly be utilized in designing future exercises in the LSU field camp program, other field camp programs, or other courses in general. While the authors were again responsible for the instruction of this program the following summer (2013), this specific exercise was not included in the curriculum due to the desire to include another exercise focused in volcanic rocks that had to be cancelled in 2012. However, the strategy of student design and discovery that was identified in the GIS project was recognized as successful and folded into the exercise.

The approach toward and introduction to GIS were successful as a component of a field camp course. This fit well as a 1 week project. Because the students were already familiar with the mapping area, and map making in general, the addition of technology to allow them to further investigate the combination of multiple data types was effective. A GIS-based project such as this could be conducted at other field camps, with the specifics of the available data tailored to the mapping areas and skills that have been utilized in that program. More generally, the approach of allowing the students to design their project through brainstorming data types that might contribute to the investigation is a strategy that can be applied to many courses both in field and classroom settings. Additionally, the practice of instructors taking advantage of situations that occur in the world or in the life of the students can be applied to a variety of learning activities to improve student interest and therefore learning and retention.

CONCLUSIONS

While the quantitative and qualitative data point toward student perceived success and student enthusiasm for the project based on the curriculum design, this conclusion is limited by the low response rate. Due to the ad-hoc nature of the curriculum design, and thus the postcamp student surveys, we cannot confirm that the students in fact improved their skills. Rather, we conclude that student engagement was enhanced as compared to a traditional mapping project that has predetermined outcomes.

By identifying a problem to investigate, selecting data types that might be useful to investigate the problem, collecting those data, combing and contrasting the data, and creating a solution to the problem, students feel a sense of ownership of the project. In addition to serving as an investigative project for the students in the LSU field camp, this project also provided an additional set of skills for spatial analysis, making the curriculum of the course more robust. This project showed that students are influenced by the place and situations around them. When given an open-ended opportunity to investigate any spatial problem, four of the six groups chose to investigate wildfire-related problems due to the strong influence that the Waldo Canyon Fire and the LSU fire had on them. This strategy of self-design made this the most meaningful assignment of the course. The connection to the project facilitated robust understanding of the geospatial principles that were the learning objectives of the project. Accordingly, the students performed better academically.

REFERENCES

Baker, M.A. 2006. Status Report on Geoscience Summer Field Camps. Washington, DC: American Geological Institute, Report GW-06.003. p. 8.

Bauer, R., Siegel, D., Sandoval, E., and Lautz, L. 2009. Integrating hydrology and geophysics into a traditional geology field course; the use of advanced project options. *In* Whitmeyer, S.J., Mogk, D.W., and Pyle, E.J., eds., Field geology education: Historical perspectives and modern approaches, Special Paper 461. Boulder, CO: Geological Society of America, p. 135–154.

Blumberg, P., 2009. Developing learner-centered teaching. San Francisco, CA: Josey-Bass.

Boyle, A.P., Maguire, S., Martin, A., Milsom, C., Nash, R., Rawlinson, S., Turner, A., Wurthmann, S., and Conchie, S., 2007. Fieldwork is good: The student perception and the affective domain. *Journal of Geography in Higher Education*, 31:299–317.

Burchfiel, B. 2007. Field camps remain an essential part of any geological curriculum, but must remain relevant. *Geological Society of America Abstracts with Programs*, 39(6):545.

Candy, P. 1991. Self-direction for lifelong learning. San Francisco, CA: Josey-Bass.

De Paor, D., and Whitmeyer, S. 2009. Innovation and obsolescence in geoscience field courses; past experiences and proposals for the future. *In* Whitmeyer, S.J., Mogk, D.W., and Pyle, E.J., eds., Field geology education: Historical perspectives and modern approaches, Special Paper 461. Boulder, CO: Geological Society of America, p. 45–56.

Dohms, P. 2011. Education and training of geologists; is field camp still relevant? *Professional Geologist*, 48(1):12–14.

Douglas, B.J., Suttner, L.J., and Ripley, E., 2009. Indiana University geologic field programs based in Montana: G429 and other field courses, a balance of traditions and innovations. *In* Whitmeyer, S.J., Mogk, D.W., and Pyle, E.J., eds., Field Geology Education: Historical Perspectives and Modern Approaches, Special Paper 461. Boulder, CO: Geological Society of America, p. 1–14.

Gravley, D., Hikuroa, D., and Borella, M. 2009. The geology of New Zealand; a new study abroad programme that investigates the geologic evolution of New Zealand through a five-week field camp coupled with a campus semester. *Geological Society of America Abstracts with Programs*, 41(7):316.

Kelley, D. 2011. Folding digital mapping into a traditional field camp program. Washington, DC: American Geophysical Union, Fall Meeting supplement, abstract ED11A-0758.

Kelso, P.R., and Brown, L.M., 2009. Integration of field experiences in a project-based geoscience curriculum. *In* Whitmeyer, S.J., Mogk, D.W., and Pyle, E.J., eds., Field geology education: Historical perspectives and modern approaches, Special Paper 461. Boulder, CO: Geological Society of America p. 57–64.

Liberty, L., Wood, S., vanWijk, K., Hinz, E., Mikesell, D., Singharajawarapan, F., and Shragge, J. 2011. The establishment of a geophysics field camp in northern Thailand. *Leading Edge*, 30(4):414–420.

Marshall, J.S., Gardner, T.W., Protti, M., and Nourse, J.A., 2009. International geosciences field research with undergraduate students: Three models for experiential learning projects investigating active tectonics of the Nicoya Peninsula, Costa Rica. *In* Whitmeyer, S.J., Mogk, D.W., and Pyle, E.J., eds., Field geology education: Historical perspectives and modern approaches, Special Paper 461. Boulder, CO: Geological Society of America, p. 77–98.

Petcovic, H., Caulkins, J., and Stokes, A. 2011. Geologists' perceptions of the value of field camp. *Geological Society of America Abstracts with Programs*, 43(5):534.

Pyle, E.J., 2009. The evaluation of field course experiences: A framework for development, improvement, and reporting. *In* Whitmeyer, S.J., Mogk, D.W., and Pyle, E.J., eds., Field Geology Education: Historical Perspectives and Modern Approaches, Special Paper 461. Boulder, CO: Geological Society of America, p. 341–356.

Stokes, A., and Boyle, A.P., 2009. The undergraduate geoscience fieldwork experience: Influencing factors and implications for learning. *In* Whitmeyer, S.J., Mogk, D.W., and Pyle, E.J., eds., Field geology education: Historical perspectives and modern approaches, Special Paper 461. Boulder, CO: Geological Society of America, p. 291–311.

Thomas, R.C., and Roberts, S., 2009. Experience one: Teaching the geoscience curriculum in the field using experiential immersion learning. *In* Whitmeyer, S.J., Mogk, D.W., and Pyle, E.J., eds., Field geology education: Historical perspectives and modern approaches, Special Paper 461. Boulder, CO: Geological Society of America, p. 65–76.

Uzunlar, N., and Lisenbee, A. 2010. Traditional field camps; an important integral component in geosciences education. *Geological Society of America Abstracts with Programs*, 42(3):9.

Whitmeyer, S.J., Mogk, D.W., and Pyle, E.J., 2009. An introduction to historical perspectives and modern approaches to field geology education. *In* Whitmeyer, S.J., Mogk, D.W., and Pyle, E.J., eds., Field geology education: Historical perspectives and modern approaches, Special Paper 461. Boulder, CO: Geological Society of America, p. vii–ix.